

# TubeInspect HD

3D measurement of small tubes and wires

**WORLD'S FIRST**

MEASURE THE ADVANTAGE



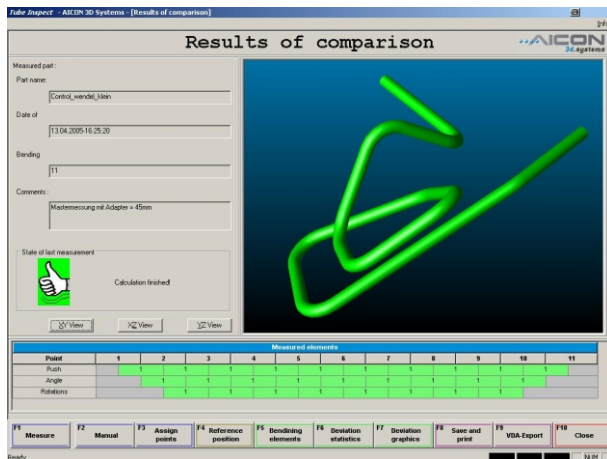
Tubes and wires shorter than 600mm are hidden in nearly all common objects. Consequently, the quality control of these parts concerns almost all industrial sectors including the automotive, electronic, household appliance, construction, and furniture industry as well as medical engineering. For example, precise dental drills are made from bent wires. Equally, this concerns fuel injector rails in automotive engineering. However, so far, it has hardly been possible to inspect the geometries of these very small, thin tubes and wires. The typically applied metrology is not able to acquire the elements of each individual small part, and even a common gauge check often proves to be unfeasible. The solution is AICON's TubeInspect HD.

The newly-developed TubeInspect HD is especially designed to suit the requirements arising in the production of bent tube and wire parts shorter than 600mm. It is based on the successful TubeInspect software that is also applied in AICON's optical tube measuring systems TubeInspect and TubeInspect S.

TubeInspect HD three-dimensionally inspects short, thin tubes and wires with diameters of 1mm up to 20mm. It checks various geometric features such as bends, length



• TubeInspect HD



• Quality control at a glance

of the part, and end-to-end distance. The measuring field comprises a volume of 500mm x 420mm x 200mm. TubeInspect HD is able to measure the geometries with a unique accuracy due to several decisive factors: It disposes

of eight digital cameras positioned close to the work piece, each having a resolution of 2 megapixels. Moreover, it uses a glass reference that is stable both with respect to shape and temperature. For the determination of the sheath tolerance, the measuring accuracy accounts for  $\pm 0.025\text{mm}$ . The measuring results are available within seconds and are displayed on the provided notebook computer. They are presented in a color-coded way following a gauge check. Thus the operator can quickly make a decision about the quality of the parts.

TubeInspect HD requires only little space. The measuring cell can easily be placed on a table and thus be integrated into an existing production environment with minimal effort.

Technical specifications	
Measurement area	500mm x 420mm x 200mm
Cameras	8 high resolution digital cameras at 2 megapixels
Tube diameter	1mm - 20mm
Measured bending angle	1° - 180°
Minimum push between two bends	bend in bend possible
Software	TubeInspect
Dimensions	700mm x 700mm x 900mm
Weight	approx. 75kg
Accessory	controlling computer with pre-installed software
Accuracy	
Sheath tolerance	$\pm 0.025\text{mm}$ (25 $\mu\text{m}$ )



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## TubeInspect HD

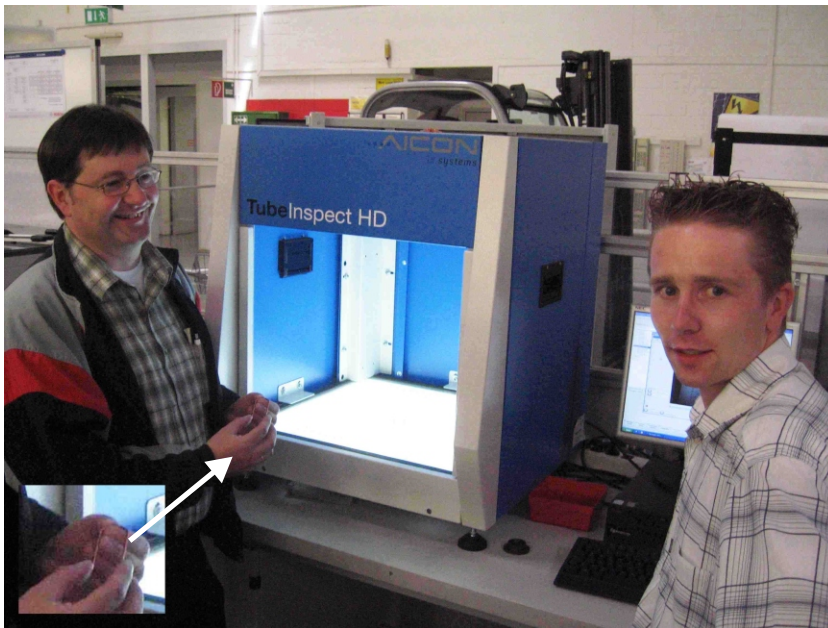
### Robert Bosch inspects coiling elements with free-form measurement

A small electric motor, the so-called starter, starts the combustion engine of a vehicle. The company Robert Bosch manufactures, among other components for automotive equipment, about 8.5 million starter armatures at its plant in Hildesheim (Germany). Specific to the model, approx. 25 coiling elements shaped of copper wire are part of each starter armature. So far, Robert Bosch hasn't been able to check the geometries of these coiling elements in an adequate way. Neither computer-based metrology nor a traditional gauge check has led to long-term satisfying measurement results. But now, AICON's optical measuring system TubeInspect HD has truly persuaded the responsible planner for the production process. The system solves the measurement task with the new free-form measurement function. Already within the first few months of application, TubeInspect HD has helped the company to improve the process quality.

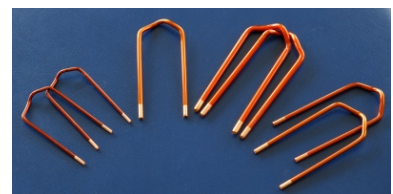


• TubeInspect HD

Yet it is absolutely necessary to comply with the ideal geometry of the coiling element. Otherwise, further processing is not possible. For example, the two end fittings must have exactly the same length, or the coiling element cannot be used for the starter armature.



• TubeInspect HD at Bosch in Hildesheim



• Coiling elements

The responsible planner reports: "With TubeInspect HD, we are now in the position to immediately detect and correct the slightest deviations of the coiling elements to their nominal geometries. Moreover, the subsequent production steps have become a lot safer."

#### Less rejects despite complex geometries

Bosch manufactures the starter armatures on seven assembly lines. In the first step, the coiling elements are made of copper wire and cut into the right length. Afterwards, they are formed into their final shape. The geometry of the coiling elements may seem to be very simple at first glance. However, it is complicated to check if the reshaped element is

true to gauge. In contrast to conventionally bent tubes and wires that arithmetically consist of lines and bends and have constant radii, most of the coiling elements have no fixed parameters. Due to the special forming process, the bends change continuously. Thus, theoretically, different radii could be present at each point of the part. These so called free-form geometries cannot be measured by conventional measurement technologies.

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## Freeform measuring principle

TubelInspect HD is dedicated to measure small tubes and wires. It merely requires that the coiling element to be measured is placed in the optical measuring cell. High-resolution digital cameras accurately measure its geometry in ten seconds. For the measurement, the system reverts to the integrated free-form measuring function that creates a solid model. TubelInspect HD compares the measurement results against the nominal geometry and the preset tolerances that are stored in the system. The result is reported in a color-coded way so that the user immediately gets the information if the element under test meets the requirements, or if any deviations occur. If required, the worker can instantly arrange for the changes of the concerned tools.

The responsible person for the production of the coiling elements explains the benefit: "Thanks to the measurement, we are now able to look for manufacturing errors systematically. Additionally, it is possible to compare the results of different assembly lines on which the same product is manufactured.

We in the production like to use our new system. The fast comparison is really convincing."

Bosch conducts these measurements in random checks during all three shifts as well as in case of breakdowns and model changes.

## Using synergies: application in construction and series production

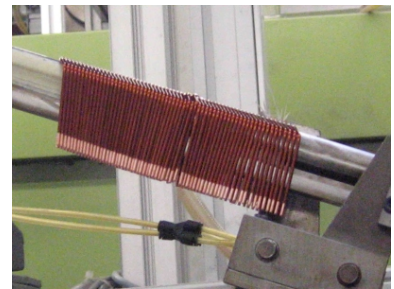
However, the system is not only used in series production. It has also proven its worth in Reverse Engineering. "In the area of construction, Bosch applies TubelInspect HD for the measurement of sample parts or for the optimization of existing coiling elements", explains AICON project engineer Matthias Kneschke who has installed TubelInspect HD at Bosch's plant. "Moreover, Bosch uses the measurement data of TubelInspect HD for the manufacturing of the production tools.

Prior to the construction of a tool, the ideal shape of the coiling element has to be defined. For finding out this ideal geometry, the members of Bosch's technical staff can-

not only rely on the construction data. In fact, the engineers also have to bear the subsequent production processes in mind.

Matthias Kneschke illustrates the procedure: "The generated ideal geometry serves as master piece. This geometry is measured with TubelInspect HD's so-called master measurement and stored in the data base of the system.

Afterwards, in series production, Bosch uses the data as a basis for comparison with the manufactured coiling elements." The tools are based on the results of this master measurement, too, as the master data can be exported in the STEP-format which is compatible to CAD. Thus it can be forwarded to the tool constructing engineers.



Coiling elements in production

## Calculable set-up times

Bosch also makes use of TubelInspect HD for setting up the production machines because it allows for a systematic correction of the tools. With the help of the measuring data, the Bosch workers can determine the elastic recovery of the material. Based on this, the exact tool setting for the ideal geometry of the coiling element can be defined. Thus not only are the set-up times calculable, they also turn out to be a lot shorter.

The production planner summarizes: "With TubelInspect HD we pick up the pace in production and save material at the same time. To us, the system means a quantum jump in measurement technology."

